

## *EDSN - Edison Demonstration for SmallSat Networks*

# **The EDSN Intersatellite Communications Architecture**

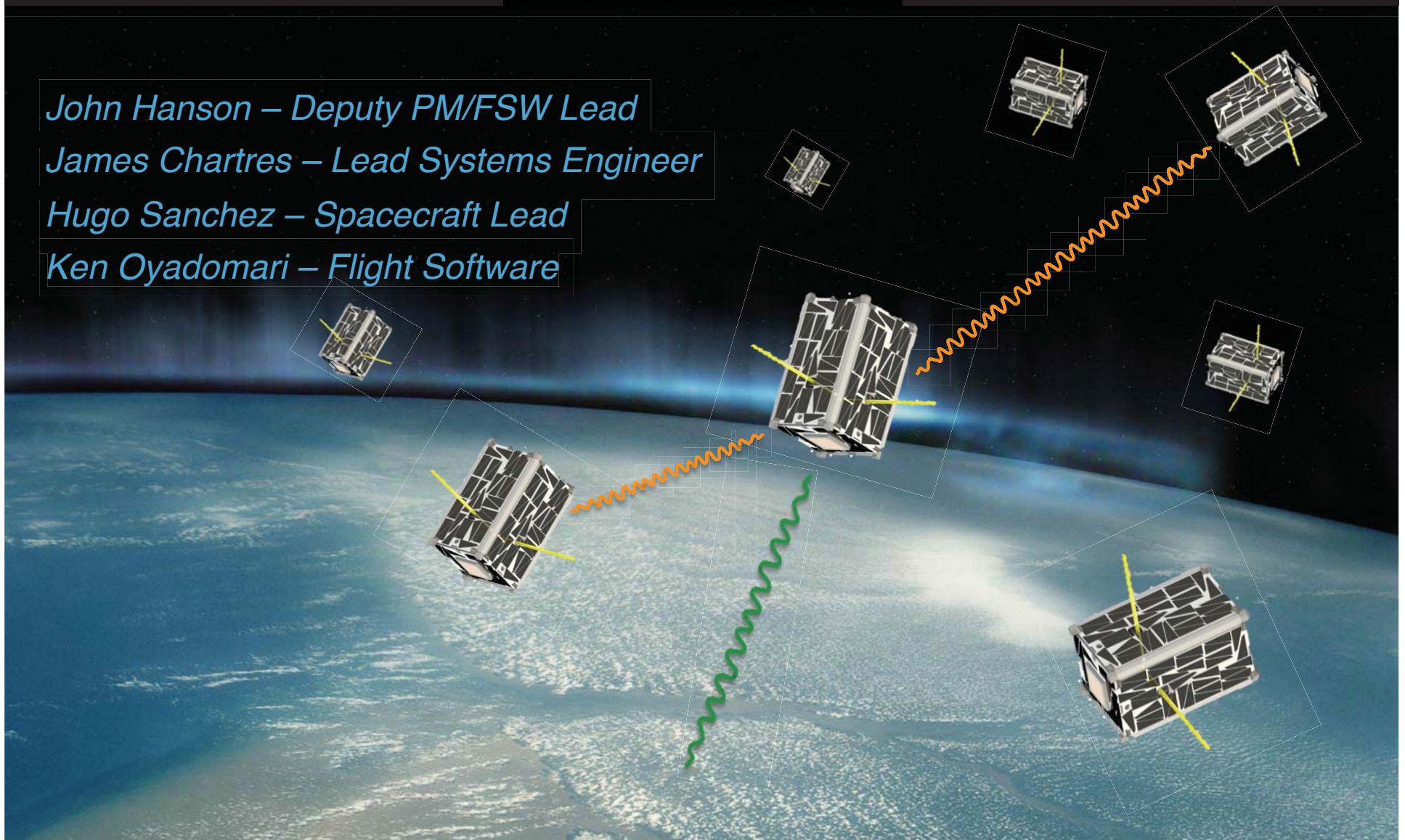
**Tuesday, 5<sup>th</sup> August, 2014**

*John Hanson – Deputy PM/FSW Lead*

*James Chartres – Lead Systems Engineer*

*Hugo Sanchez – Spacecraft Lead*

*Ken Oyadomari – Flight Software*





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# Science with Swarms

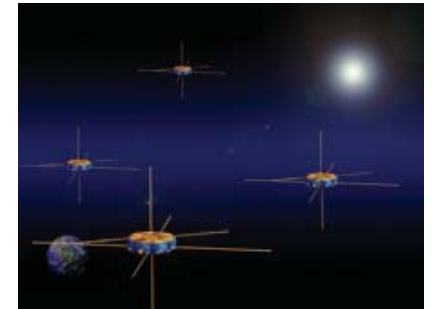
- Probing Earth-Sun interactions with gradient measurements of magnetosphere properties
- Synthetic aperture radar
- Multi-point tomographic measurements
- Geopotential measurements
- Large sparse array telescopes
- Coronagraph based missions
- Explore properties of other planets, comets and near-Earth objects



[http://www.darpa.mil/.../System\\_F6.aspx](http://www.darpa.mil/.../System_F6.aspx)



[http://www.esa.int/.../About\\_Proba-3](http://www.esa.int/.../About_Proba-3)



<http://mms.gsfc.nasa.gov/>



<http://gracetellus.jpl.nasa.gov/>

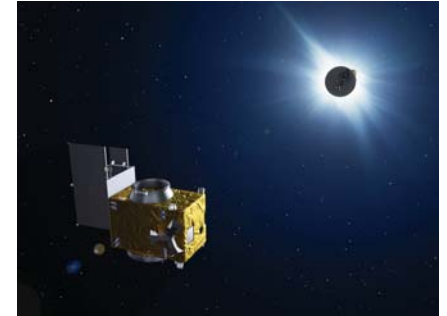


# Cubesat Challenges

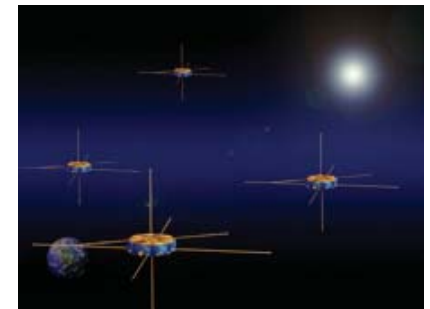
- Low electric power availability
- Limited ADCS hardware
- Ground support systems
- Maximizing available mass and power for payloads



[http://www.darpa.mil/.../System\\_F6.aspx](http://www.darpa.mil/.../System_F6.aspx)



[http://www.esa.int/.../About\\_Proba-3](http://www.esa.int/.../About_Proba-3)



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# EDSN Mission Objectives

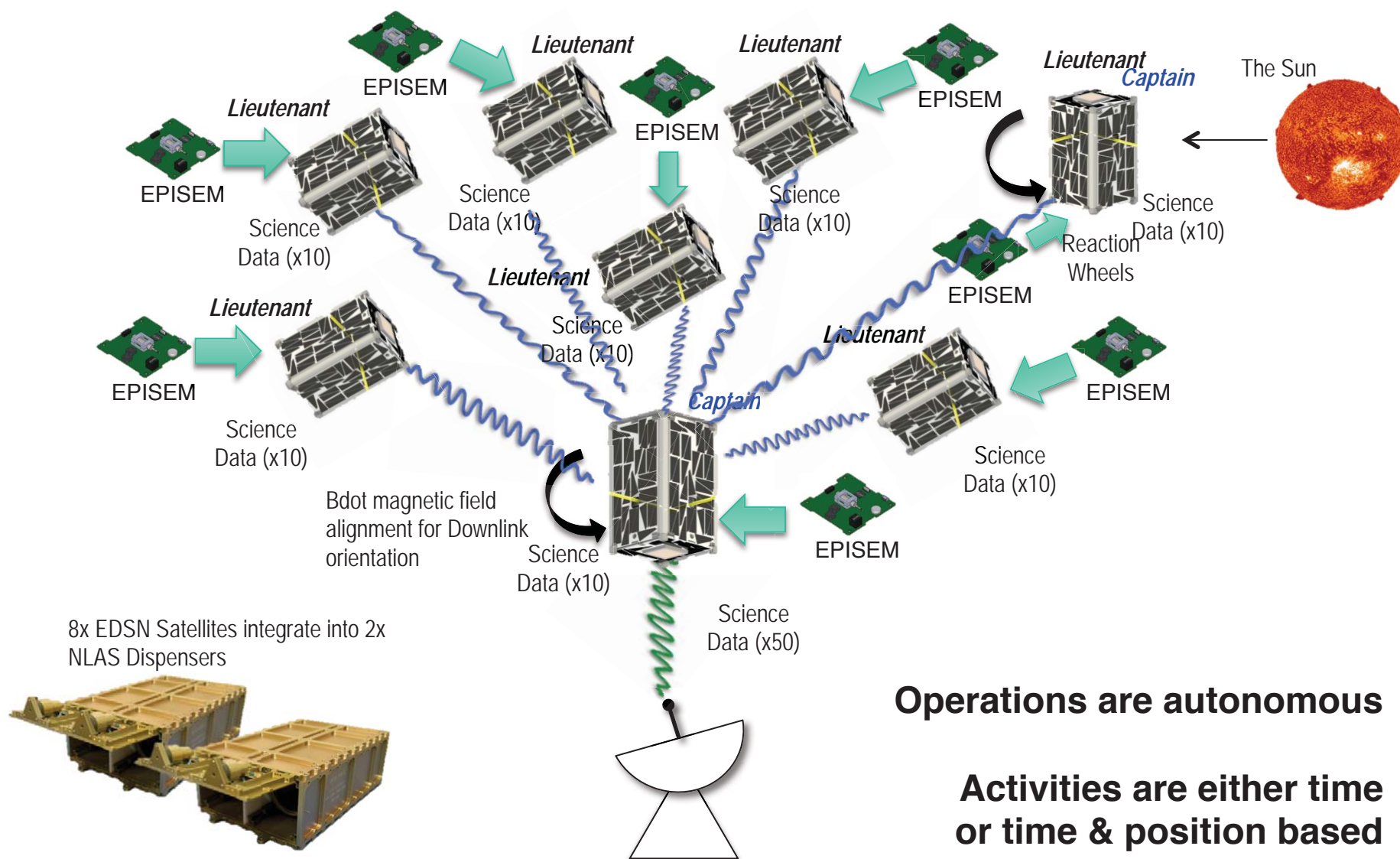
## Mission Goal

**Demonstrate that a swarm of satellites is capable of collecting multi-point science data and transferring the data to the ground**

## Mission Objectives

- 1. Flight demonstrate one-way space-to-space data transfer whereby at least 2 satellites transfer data to a third satellite, which then transfers the data to the ground**
- 2. Flight demonstrate a system to collect multi-point science measurements, transfer science measurements to another satellite and transfer to the ground**
- 3. Flight demonstrate a reaction wheel based pointing system.**
- 4. Assess the viability of satellites built with Commercial Off The Shelf (COTS) components to operate for 60 days**

## Mission Overview



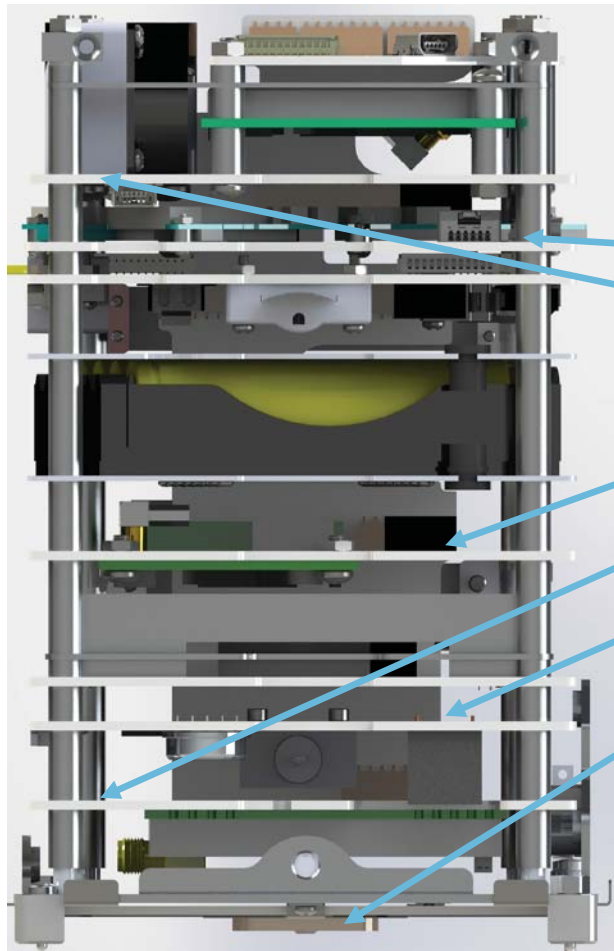


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# EDSN Spacecraft Characteristics



- 1.5U Cubesat
- Primary processor – Nexus S Phone
- MicroHard MHX2420 S-band (downlink)
- Stensat UHF Beacon
- AstroDev Li-1 UHF transceiver (crosslink)
- EPISEM payload
- Novatel OEMV-1 GPS Receiver
- Li-Ion Batteries (2800 mAh)
- 1 W orbit average power



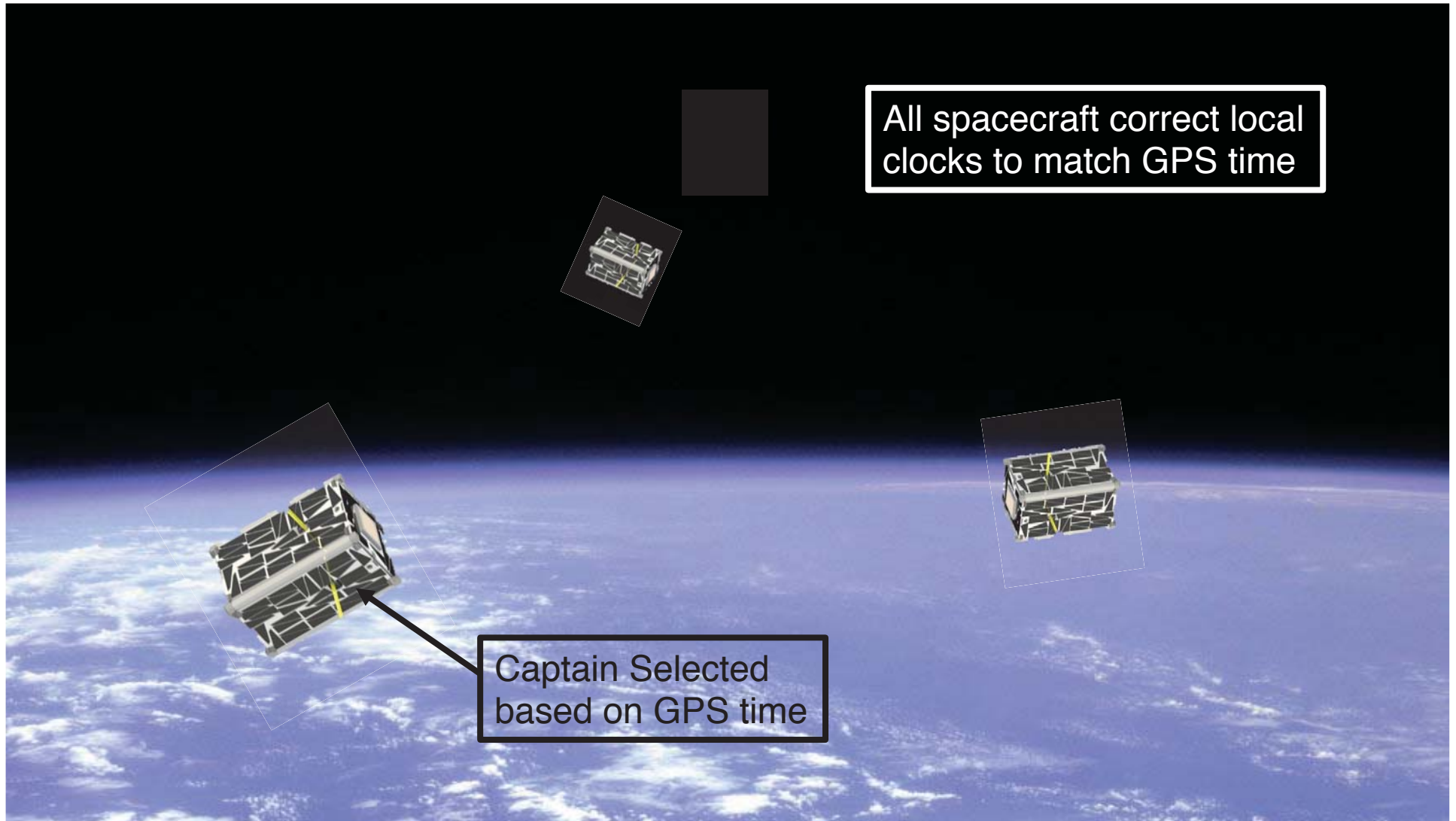


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## 1. Acquire GPS Solution

## Comms Architecture





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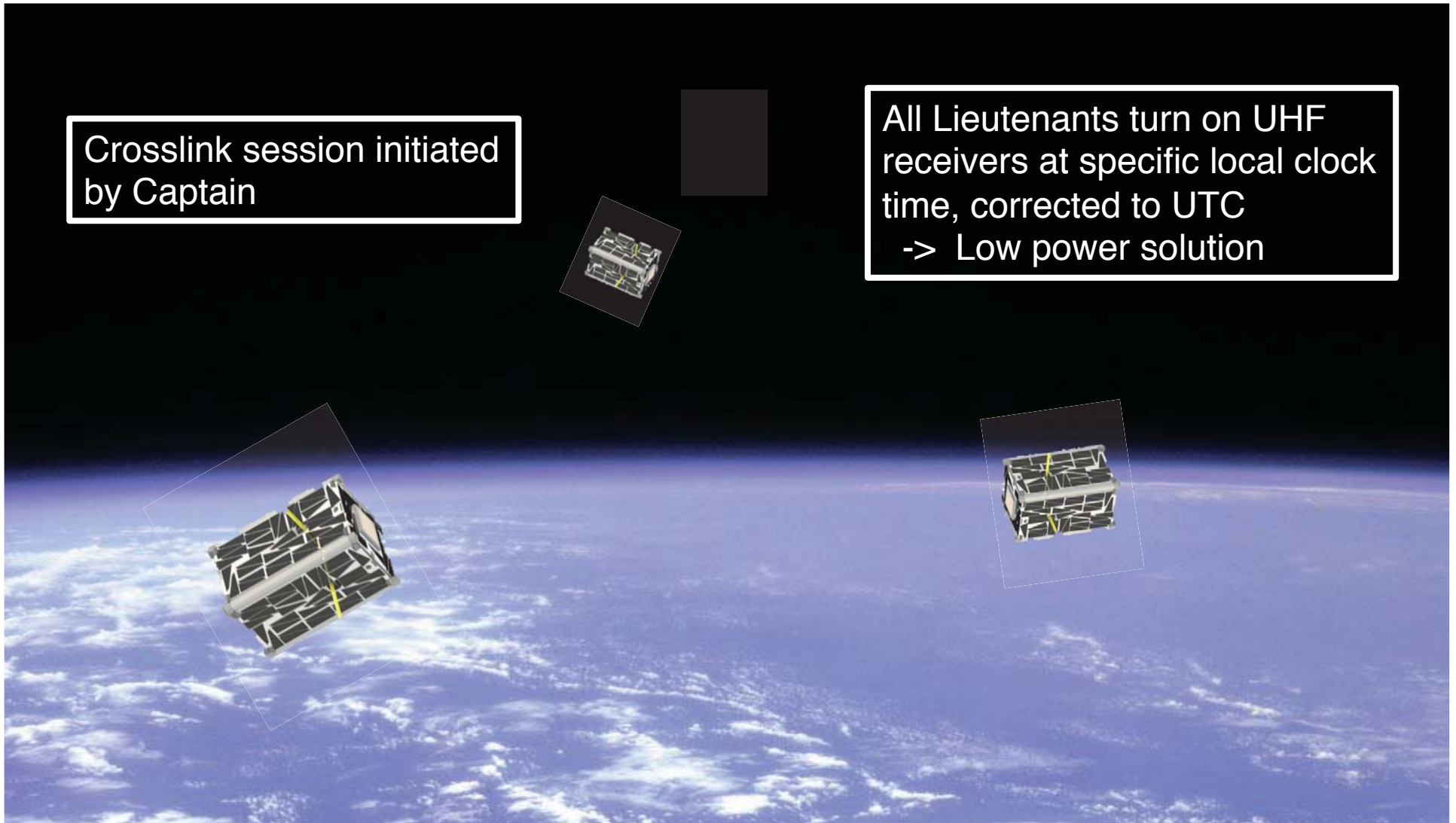


## 2. Initiate Crosslink Session

## Comms Architecture

Crosslink session initiated  
by Captain

All Lieutenants turn on UHF  
receivers at specific local clock  
time, corrected to UTC  
-> Low power solution







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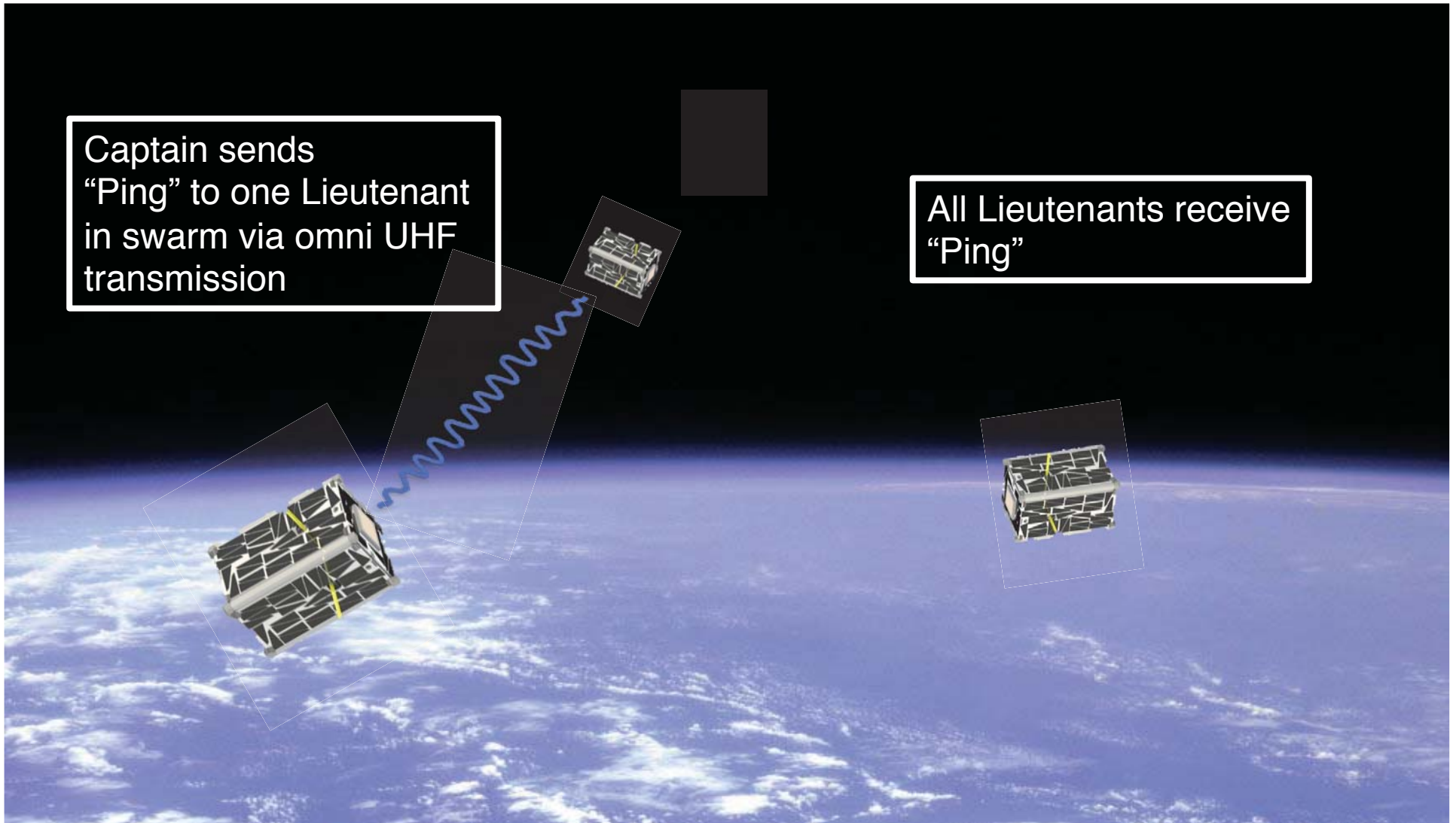


## 2a. Initiate Crosslink Transaction

## Comms Architecture

Captain sends  
“Ping” to one Lieutenant  
in swarm via omni UHF  
transmission

All Lieutenants receive  
“Ping”



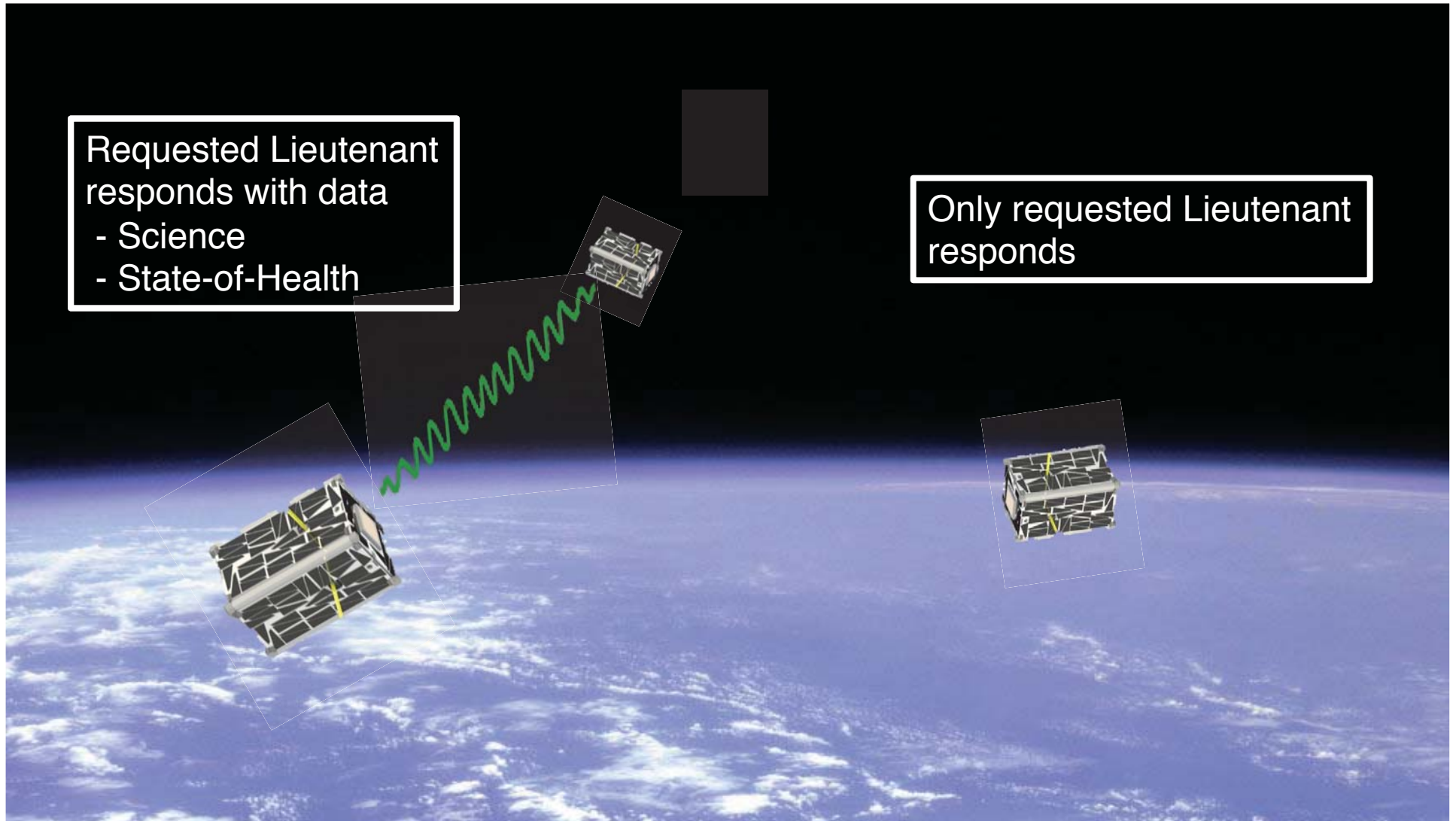


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## 2b. Collect Crosslink Data

## Comms Architecture





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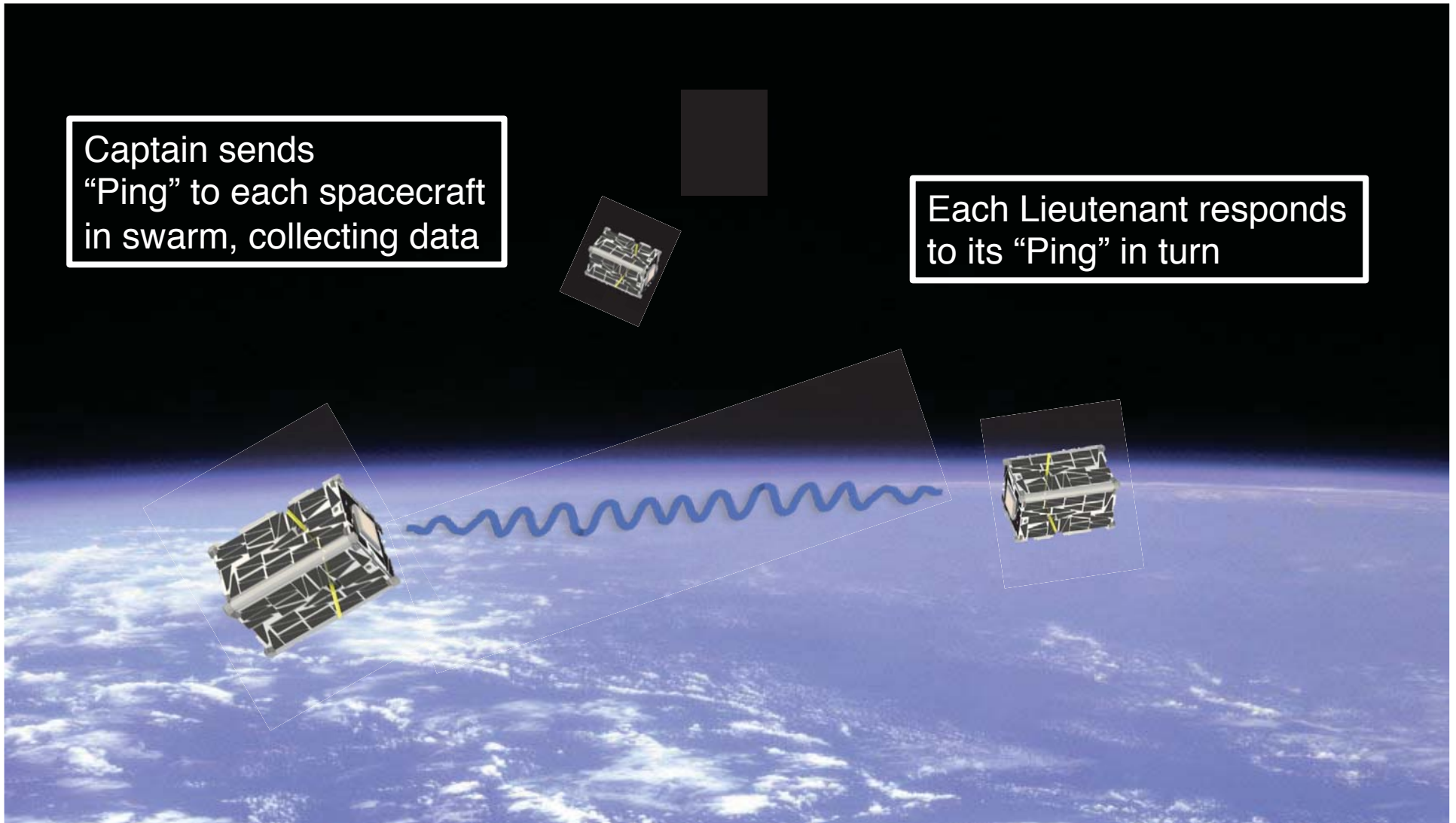


## 2c. Collect Data from Swarm

## Comms Architecture

Captain sends  
“Ping” to each spacecraft  
in swarm, collecting data

Each Lieutenant responds  
to its “Ping” in turn







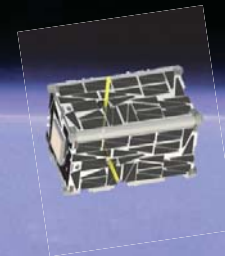
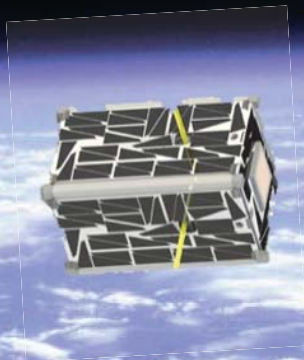
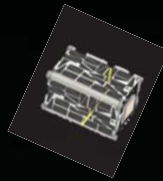
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### 3. Initiate Downlink Activity

## Comms Architecture

Captain aligns with local magnetic field





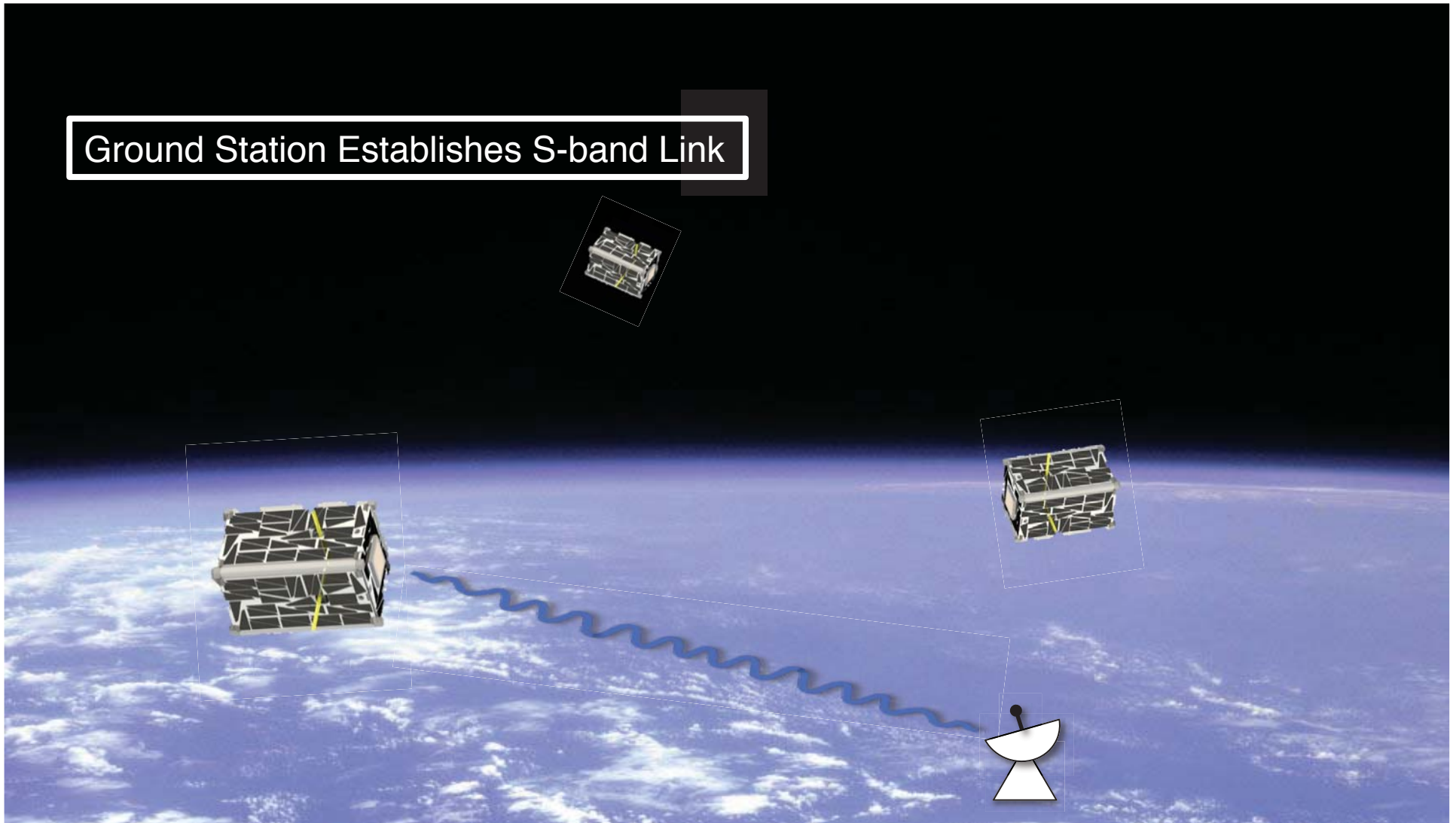
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## 4. Send Data to Ground

## Comms Architecture

Ground Station Establishes S-band Link





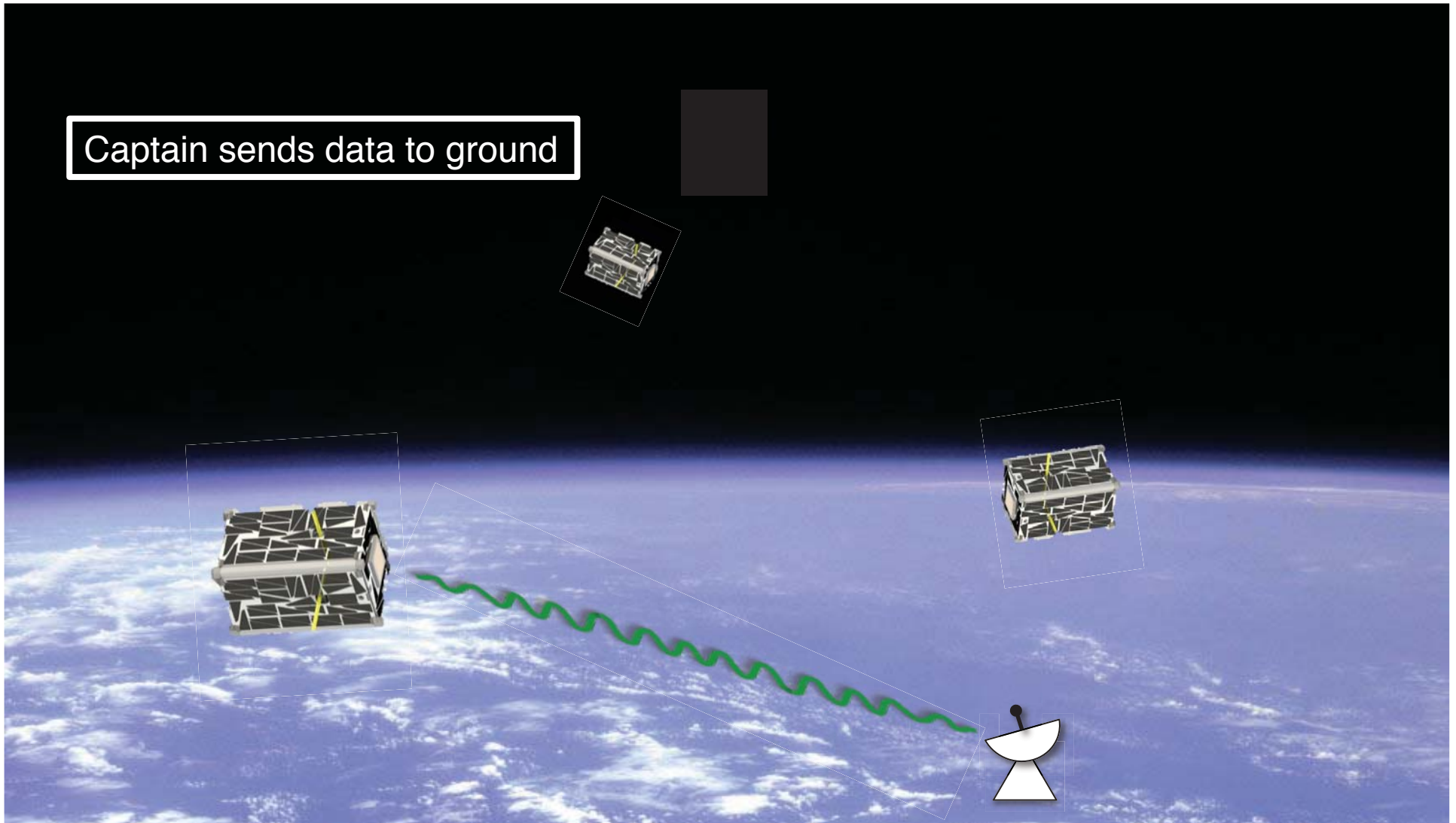
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## 4. Send Data to Ground

## Comms Architecture

Captain sends data to ground





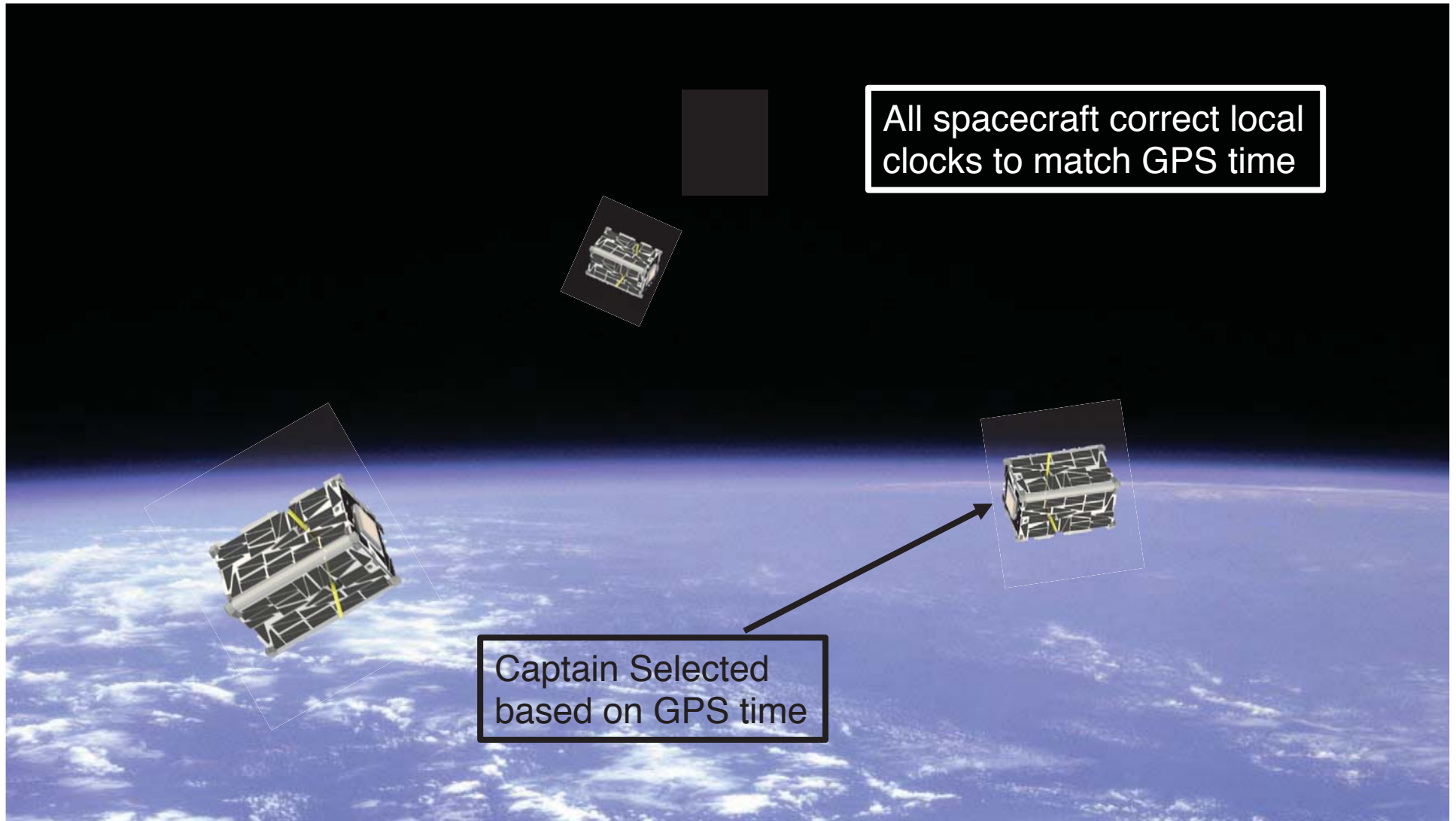


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## 1. Acquire GPS Solution ...

## Comms Architecture



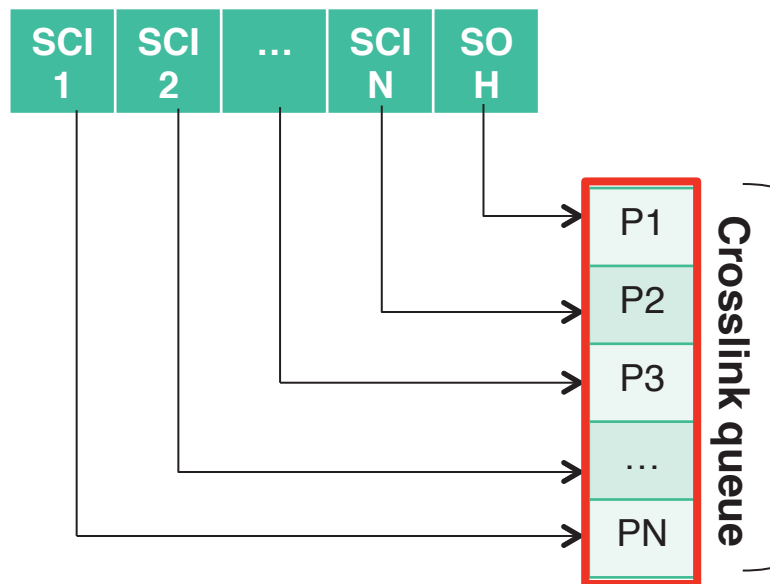


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# Crosslink

## Crosslinked Packets from LT



## downlink stacks

CPT	LT1	LT2	LT3	...	LT7
PtP	P1	P1	P1	...	P1
SOH	P2	P2	P2	...	P2
SC1	P3	P3	P3	...	P3
SC2	P4	P4	P4	...	...
SC3	P5	P5	...	...	...
...	P1-0	...	...	...	...
	P2-0				
	P3-0				
	P4-0				
	P5-0				
	...				

Packets in the downlink stack **from previous sessions** or major cycles are pushed down in the stack



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Session

GPS Time

Lt #1 Rec'vr On

SC#1 Clock Error

Lt #2 Rec'vr On

SC#2 Clock Error

Cpt Ping #1

Cpt Clock Error Buffer

Lt #1 Transmit

N packets transmitted in fixed window

Cpt Rec'vr Window

Cpt Rec'v Buffer

Cpt Ping #2

Cpt Transaction Buffer

Lt #2 Transmit

Cpt Rec'vr Window



Cpt Ping #7

Lt #7 Transmit

Cpt Rec'vr Window







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## EDSN Demonstrates ...

- Time synchronized measurements on spatially distributed platforms
- One-way operation of the swarm (data collection) through a single spacecraft that is in periodic contact with the ground
- Autonomous operation of the swarm (i.e. without intervention from ground control)
- Redundancy in swarm operations through the simple, pre-scripted periodic hopping of the Captain





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# Future Enhancements

- Routing of ground commands through network
- Autonomous configuration and control of the network by the swarm
- Time synchronized measurements by command from the Captain
- Improved synchronization of time across the swarm
- Improved formation knowledge through DGPS
- Mapping of network topology
- Routing of packets through the network by multiple hops
- Multiple Captains
- Passing of large data files between spacecraft (e.g. image files)
- Prioritization of data messages by the Captain or Lieutenant for downlink
- Addition of ACK/NACK protocol
- Multiple ground stations to increase data throughput
- Addition of standard network layer to the system to take advantage of COTS software and protocols
- Interlinking of multiple Captains to create a “cluster of clusters”.





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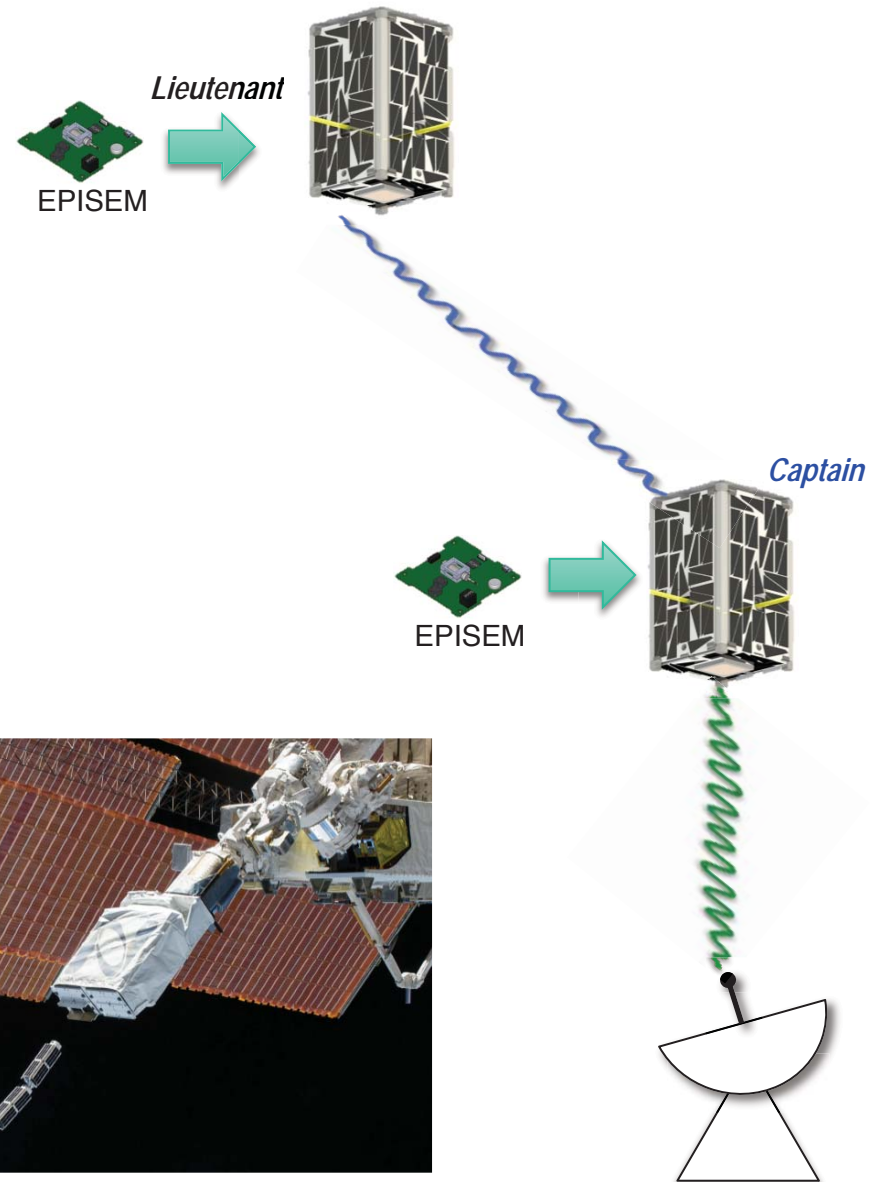
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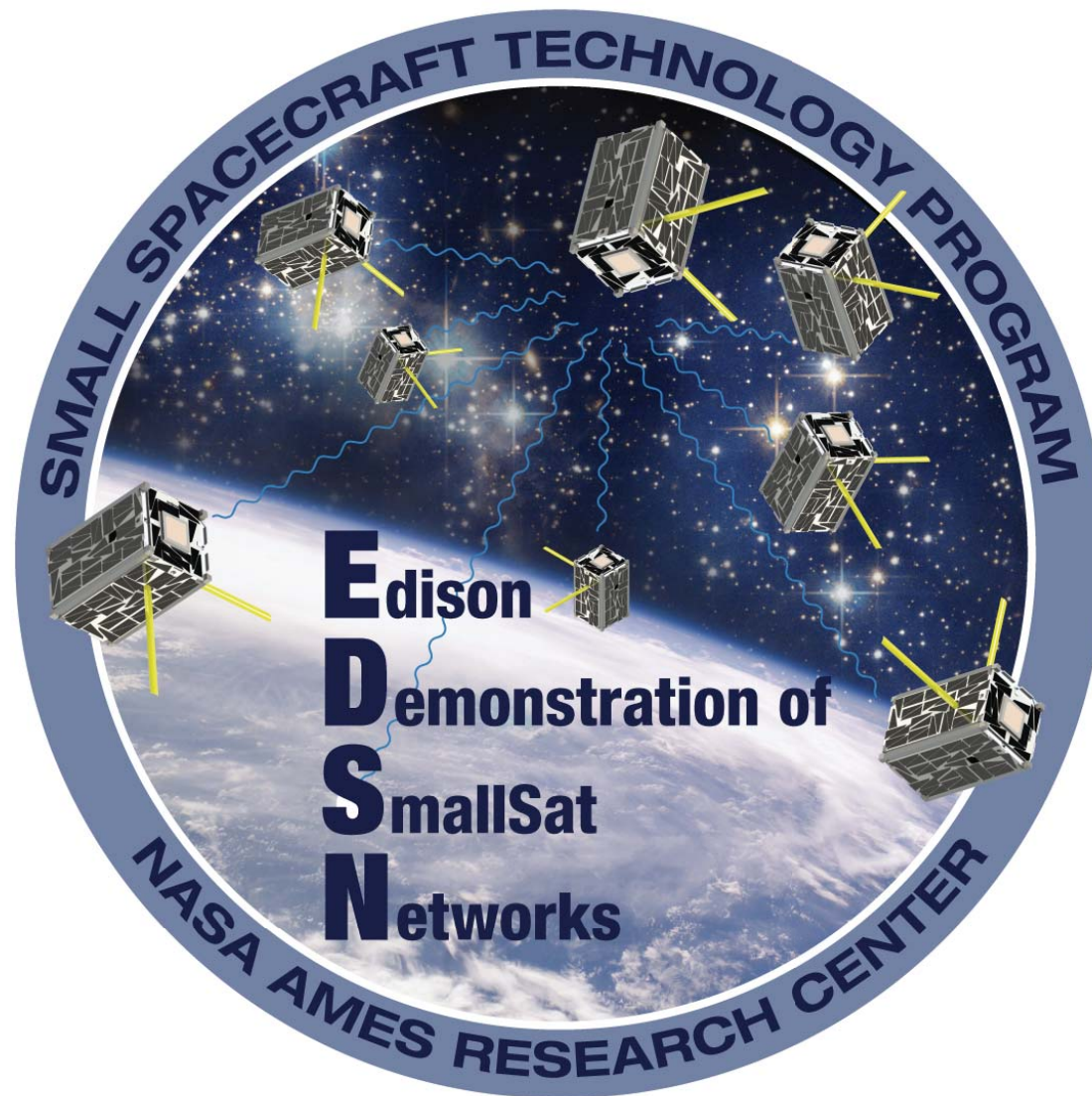
# Future Enhancements

- Routing of ground commands through network
- Autonomous configuration and control of the network by the swarm

## Nodes

- Demonstration of swarm control technologies
- Delivery to Nanoracks in September, 2014
- Downlaunch from ISS in Q1, 2015





*Questions?*

*Questions?*

